MULTI-DIMENSIONAL NANOMETRIC DISPLACEMENT POSITIONER

FIELD OF INVENTION

This invention relates to finely adjustable positioners, and more particularly, to a finely adjustable positioner capable of minute, nanometric adjustments in each of three dimensions.

BACKGROUND OF THE INVENTION

Standards for scientific and industrial equipment have specified ever finer and more accurate component positioning alignments within narrow ranges. Particularly, optical and laser equipment require small displacement capabilities.

Adjustable mirror mounts and X, Y, Z positioners have been used in optical bench elements which were designed to achieve selective and fine movements. In such X, Y, Z positioner designs, three finely pitched micrometric screws drove three sliding or rolling carriages. These carriages and their respective drive screws are structurally interconnected into a three dimensional displacement drive assembly. Spring loading of such interconnected elements is used to eliminate play in the carriage ways; however, undesirable cumulative error displacements seriously interfere with the operation of the positioner assembly in the micrometric range. As optics and fiber optics applications have increased, design demands have dictated optical work benches capable of extremely small displacements, down into the ranges of wavelengths of the light spectrum. The more minute the desired displacement, the greater tha naturally occurring effect of cumulative error resulting from carriage play and the spring loading of interconnected assembly elements.

Previous attempts at addressing the problems of cumulative error and mechanical backlash include adjustable mirror mount devices employing flexure pin hinges for adjusting two angles to achieve substantially reduced backlash. Flexure pins used as low backlash hinges for small angular displacements are featured in Laser and Fabry Perot cavity alignment structures. Flexure pivot principle based devices include the "Micro Positioning Base" manufactured by Newport Corporation (NRC); and, one dimensional flexure pivot stages assembled by Physitec (catalog numbers 42-1050 and 42-1055).

U.S. Pat. No. 4,139,948 issued to Tsuchiya discloses a micromanipulator based on the principle of the differential lever, wherein a fine displacement is achieved by the interaction of two separate micrometers **36** and **38** (FIG. **1**) to produce an accuracy of 0.1 to 0.2 micron Linear Movement. Such a device was used to align the core ends of optical fibers.

U.S. Pat. No. 4,331,384 to Eisler is directed to an optomechanical system, built up of basic elements with a number of orthogonal degrees of freedom. This system claims to achieve three degrees of freedom down to a resolution in each of three directions of 0.2 micrometers; the overall displacement in the interferometrical range equal a movement which is achieved by a separate assembly in each direction of movement. A lever mechanism with a high transmission ratio through a differential and standard micrometer screw is used to achieve this fine resolution, and is discussed in U.S. Pat. No. 4,209,233, also to Eisler.

As industry standards and optics requirements have evolved, interferometrical resolution and accuracy is affected both by the inherent backlash in each orthogonal degree of freedom as well as cross-talk between the independent elements, where each element controls movement in a separate direction and degree. While problems like backlash and cross-talk have not been overwhelming in the micrometric ranges of displacement, these problems are of greater moment in the nanometric ranges which include optical resolutions of the order of magnitude of the wave length of light. Therefore, there is a need for a more precise and sensitive optical positioner or bench tool which is capable of accurate operation in more precise measurements and ranges.

SUMMARY OF THE INVENTION

The invention disclosed herein is directed to a multidimensional fine-adjustment linear nanometric displacement apparatus including a monolithic housing having a main frame portion and defining a support ring with a centrally positioned aperture. The support ring is movable with respect to the main frame portion. Also defined within the monolithic housing is a pair of rigid levers, each forming flexural connections with the support ring, each connection located about the circumference of the support ring and each lying respectively, along the X- and Y- axes.

Each of the rigid levers is linked to a flexure link which connects to the centrally positioned support ring. Each of the flexure links and rigid levers are joined at a flexure fulcrum. The lever is significantly longer than the flexure link, so that as the rigid lever is moved, a substantial reduction ratio results and the support ring moves a nanometric displaced distance along either the X- or Y- axes.

A manual knob provides a means for driving each lever separately against the support ring, moving the ring only in a single line of action or dimension with little backlash or cross talk between X- and Y- axis movement. By being integral with the monolithic housing, each lever provides separate nanometric displacement through principles of a compound lever. The manual knob controls a finely pitched tapered screw which drives the rigid lever.

Mounted within the support ring is an elongated tubular adjustment mechanism projecting outward from the center of the monolithic housing in the Z- axis dimension, orthogonal to both the first and second linear dimensions.

The tubular adjustment mechanism includes an inner holder tube having at least one projecting member forming an outward radially directed flange along the outer surface of this inner holder tube. An adjustment body tube surrounds the inner holder tube and forms a flexure lever which is flexually linked to the body tube, such that the flexure lever is biased against the flange projecting outward from the inner holder tube. An outer drive sleeve is capable of manual control and has an inner surface tapered bore contacting a radially directed rod affixed to the lever, so that the lever bends at its flexure fulcrum as the rod is contacted by the bore of the sleeve. The lever then presses against the flange of the inner holder tube, causing the holder tube to move axially in a direction opposite the axial direction of movement of the outer driving tube, whereby nanometric displacement of the tubular adjustment mechanism proceeds along the third linear dimension.